Forecasting the impact of a sudden stratospheric warming on the ionosphere.
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A Whole Atmosphere Model (WAM) has been used to explore the physical connection between large-scale atmospheric process, such as a sudden stratospheric warming (SSW), and the dynamics and electrodynamics of the thermosphere-ionosphere system. WAM produces SSWs naturally without the need for external forcing. The classical signatures of an SSW appear in the model with a warming of the winter polar stratosphere, a reversal of the temperature gradient, and a breakdown of the stratospheric polar vortex. Substantial changes in the amplitude of stationary planetary wave numbers 1, 2, and 3 occur as the zonal mean zonal wind evolves (see Figure 1).

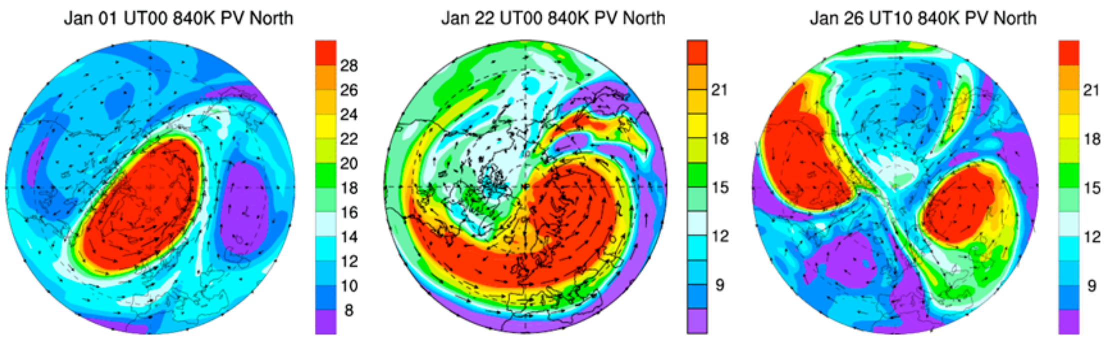

Figure 1. Illustration of planetary wave zero, 1, and 2 on the isentropic potential vorticity surface at 840K, at an approximately altitude of 30 km in the stratosphere, from WAM. On the left is a symmetric vortex (wave zero), middle is a displaced vortex (wave 1), and on the right a split vortex (wave 2).

In the lower thermosphere the amplitude of diurnal, semidiurnal, and terdiurnal, eastward and westward propagating tidal modes change substantially during the event. The increase in the magnitude of the terdiurnal tide (TW3) in the lower thermosphere has the clearest correlation with the SSW, with a time delay of about three days. An increase in TW3 in the lower thermosphere alters the local time variation of the electrodynamic response. The day-to-day changes in the lower thermosphere winds from WAM are shown to introduce variability in the magnitude of dayside low latitude electric fields, with a tendency during the warming for the dayside vertical drift to be larger and occur earlier, and for the afternoon minimum to be smaller. The numerical simulations suggest that a major SSW, with a magnitude seen in January 2009, could cause large changes in lower thermosphere electrodynamics and hence in total electron content.

In order to follow a real atmospheric event, such as the January 2009 SSW, WAM has been integrated into the GSI data assimilation system. The WAM-GSI-IAU model data assimilation system was used to simulate the January 2009 SSW interval. The model was able to follow the real SSW with high fidelity, and predict the impact on the dynamo winds in the lower thermosphere many days in advance. Just as in the free run, the results again indicated a much stronger increase in the TW3. Figure 2 shows that the electrodynamic response is in good agreement with the Jicamarca ISR observations.

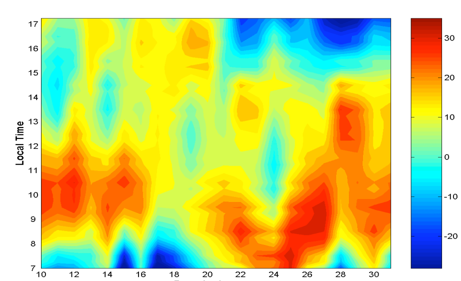

Figure 2. Illustration of the change in dayside electrodynamics during the sudden stratospheric warming of Januray 2009, in agreement with observations.